BULLETIN 414 NOVEMBER, 1927

Canada Thistle, *Cirsium arvense* Tourn.

Field Thistle, Creeping Thistle

Freda Detmers

OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

OHIO AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

JULIUS F. STONE, *President* ..... Columbus
MRS. ROBERT G. PATERSON, *Vice President* ..... Columbus
LAWRENCE E. LAYBOURNE ..... Springfield
EGBERT H. MACK ..... Sandusky
H. S. ATKINSON ..... Columbus
HARRY A. CATON ..... Coshocton
JOHN KAISER ..... Marietta
CHARLES V. TRUAX, *Director of Agriculture* ..... Columbus
CARL E. STEEB *Secretary* ..... Columbus

STATION STAFF

C. G. WILLIAMS, *Director*

AGRONOMY

R. M. SALTER, M. S., *Chief*
C. E. THORNE, D. Sc., *Consulting Chief*
J. W. AMES, M. S., *Associate*
G. W. CONREY, Ph. D., *Associate*
L. E. THATCHER, Ph. G., *Associate*
F. A. WELTON, Ph. D., *Associate*
F. E. BEAR, Ph. D., *Asso.* (Columbus)
J. B. PARK, Ph. D., *Asso.* (Columbus)
C. J. WILLARD, Ph. D., *Asso.* (Columbus)
E. E. BARNES, M. S., *Asso.* (Columbus)
H. W. BACHELOR, M. S., *Associate*
L. D. BAVER, B. S., *Assistant*
H. L. BORST, M. S., *Asst.* (Columbus)
MABEL CORBOULD, B. S., *Assistant*
I. H. CURIE, B. S. *Assistant*
J. S. CUTLER, M. S., *Assistant*
C. E. DIKE, B. S., *Assistant*
F. R. DREIBELBIS, B. S., *Assistant*
R. W. GERDEL, M. S., *Assistant*
T. C. GREEN, B. S., *Assistant*
ADRIAN J. HARTZLER, B. S., *Assistant*
G. M. MCCLURE, M. S., *Asst.* (Columbus)
J. T. MCCLURE, B. S. A., *Assistant*
V. H. MORRIS, M. A., *Assistant*
M. T. MYERS, M. S., *Asst.* (Columbus)
A. H. PASCHALL, B. S., *Assistant*
C. A. PATTON, *Assistant*
C. J. SCHOLLENBERGER, B. A., *Assistant*
R. H. SIMON, A. M., *Assistant*
G. H. STRINGFIELD, B. S. A., *Assistant*
C. L. THRASH, M. S., *Asst.* (Columbus)

ANIMAL INDUSTRY

G. BOHSTEDT, Ph. D., *Chief*
R. M. BETHKE, Ph. D., *Associate*
B. H. EDGINGTON, D. V. M., *Associate*
C. H. HUNT, Ph. D., *Associate*
D. C. KENNARD, B. S., *Associate*
D. S. BELL, M. S., *Assistant*
C. H. KICK, M. S., *Assistant*
L. B. NETTLETON, *Assistant*
W. L. ROBISON, M. S., *Assistant*
B. L. WARWICK, D. V. M., Ph. D., *Asst.*
GEORGE ZINZALIAN, B. Ch. E., *Assistant*

BOTANY AND PLANT PATHOLOGY

H. C. YOUNG, Ph. D., *Chief*
R. C. THOMAS, M. A., *Associate*
W. G. STOVER, Ph. D., *Asso.* (Columbus)
R. B. WILCOX, M. S., U. S. D. A.
L. R. HESLER, Ph. D., *Assistant*
L. M. COOLEY, B. S., *Assistant*
CURTIS MAY, M. S., *Assistant*
A. G. NEWHALL, M. S., *Assistant*
H. A. RUNNELS, M. S., *Assistant*
J. D. SAYRE, Ph. D., *Assistant*
PAUL E. TILFORD, M. S., *Assistant*
J. D. WILSON, Ph. D., *Assistant*

DAIRY INDUSTRY

C. C. HAYDEN, M. S., *Chief*
W. E. KRAUSS. Ph. D., *Assistant*
C. F. MONROE, M. S., *Assistant*
A. E. PERKINS, M. S., *Assistant*

ENGINEERING (AGR.)

G. W. MCCUEN, B. S., *Chief* (Col.)
C. O. REED, B. S., *Associate* (Columbus)
P. B. POTTER, B. S., *Asst.* (Columbus)
B. M. STAHL, M. S., *Asst.* (Columbus)
E. A. SILVER, B. S., *Asst.* (Columbus)

ECONOMICS (RURAL)

J. I. FALCONER, Ph. D., *Chief* (Col.)
J. F. DOWLER, B. S., *Asst.* (Columbus)
C. W. HAUCK, *Assistant* (Columbus)
G. F. HENNING, M. S., *Asst.* (Columbus)
E. K. JACKSON, B. A., *Assistant*
C. E. LIVELY, M. A., *Asst.* (Columbus)
C. G. MCBRIDE, M. S., *Asst.* (Columbus)
H. R. MOORE, B. A., *Asst.* (Columbus)
F. L. MORISON, M. S., *Asst.* (Columbus)
E. C. NEWCOMER, *Asst.* (Columbus)

ENTOMOLOGY

J. S. HOUSER, M. S. A., *Chief*
L. L. HUBER, Ph. D., *Associate*
HERBERT OSBORN, D. Sc., *Asso.* (Col.)
C. R. CUTRIGHT, Ph. D., *Associate*
C. R. NEISWANDER, Ph. D., *Associate*
G. A. FILINGER, M. S., *Assistant*
H. L. GUI, M. S., *Assistant*
E. G. KELSHEIMER, M. S., *Assistant*
J. B. POLIVKA, M. S., *Assistant*
LOUIS A. STEARNS, M. S., *Assistant*

FORESTRY

EDMUND SECREST, B. S., *Chief and Asso. Dir. of Sta.* (State Forester)
J. J. CRUMLEY, Ph. D., *Asso.* (Athens)
O. A. ALDERMAN, M. F., *Assistant*
F. W. DEAN, B. S., *Assistant*
B. E. LEETE, M. F., *Asst.* (Portsmouth)
L. J. LEFFELMAN, M. F., *Assistant*
R. R. PATON, M. F., *Assistant*

HOME ECONOMICS

FAITH R. LANMAN, B. S., *Chief* (Col.)
HUGHINA MCKAY, M. A., *Asso.* (Col.)
MARY ANNE BROWN, B. S., *Asst.* (Col.)

HORTICULTURE

J. H. GOURLEY, M. S., *Chief*
F. H. BALLOU, *Asso.* (Newark)
JOHN BUSHNELL, Ph. D., *Associate*
F. S. HOWLETT, Ph. D., *Associate*
J. S. SHOEMAKER, Ph. D., *Associate*
DONALD COMIN, B. S., *Assistant*
C. W. ELLENWOOD, *Assistant*
I. C. HOFFMAN, M. S. *Assistant*
I. P. LEWIS, B. S., *Assistant*
ROY MAGRUDER, B. S., *Assistant*
W. W. WIGGIN, M. S. *Assistant*

MISCELLANEOUS

W. H. ALEXANDER, *Climatologist* (Col.)
W. K. GREENBANK, *Editor*
W. H. KRAMER, *Bursar*
MRS. GRACE G. GERDEL, M. S., *Librarian*

DISTRICT AND COUNTY EXPERIMENT FARMS

M. A. BACHTELL, B. S., *In Charge*

C. H. CRAWFORD, B. S., *Supt.*, Trumbull
WALTER MAHAN, *Supt.*, Belmont
S. C. HARTMAN, M. S., Southeast, Wash.
H. R. HOYT, *Supt.*, Paulding, (Wooster)
O. N. RILEY, Foreman. Wash. Truck Farm
H. W. ROGERS, B. S., *Supt.*, Madison & Miami
L. W. SHERMAN, *Supt.*, Mahoning
H. M. WACHTER, *Supt.*, Southwest
W. E. WEAVER, *Supt.*, Hamilton & Clermont
J. T. WILSON *Supt.*, Northeast

CONTENTS

This page intentionally blank.

CANADA THISTLE, *Cirsium arvense* Tourn.
Field Thistle, Creeping Thistle

FREDA DETMERS

The rapid increase and spread of Canada thistle practically throughout Ohio has brought it into prominence and has gained for it the reputation as being one of the worst weeds in the State.

It was deemed worth while, therefore, to make a detailed study of the weed, its introduction into the State, distribution, life history, means of propagation, natural enemies, and methods of eradication and control. The study was begun in the fall of 1924 and continued through 1925 and 1926. Though the study is not finished, enough information has been gained to make it seem expedient to publish the results.

NOMENCLATURE

The plant, whose most commonly accepted name is *Cirsium arvense,* has passed through several vicissitudes of nomenclature and description. Carl von Linné, the great Swedish botanist, is credited with being the first to name and describe it. However, there were a number of antilinnean authors of names and descriptions. Lund and Rostrup (34) cite Fabius Columna (13) as probably the earliest on record. "Columna in 1616 called our thistle *Ceanothos Theophrasti.*" Ceanothos, from the Greek and meaning "a kind of thistle," is applied in the manuals of today to an entirely different group of plants.

In 1623 Caspar Bauhin (6) called the plant *Carduus in avena proviens.* Bauhin was the first to use Carduus, the latin name for thistle, and to recognize the habitat grain fields by the specific designation "in avena proviens." J. Bauhin (7) in 1651 named it *Carduus serpens laevigatus,* thereby recognizing its creeping habit, "serpens", and smooth stem and leaves, "laevigatus". C. Bauhin (5) in 1671 gave the name *Carduus vinearum repens, "Repens vinearum"* signifying creeping roadside. In 1686 the name *Carduus vulgatissimus* (43) *viniarum* appeared, this name meaning common roadside thistle.

In 1687 Theodorus Jacobus Tabernaemontanus (53) described and illustrated this thistle under the name *Carduus arvensis,* the

thistle of cultivated fields. According to his description and illustrations the plant has a thick fusiform tap root with many smaller root branches; the stem branches freely; the leaves are few and large with margins sparingly lobed and beset with minute thorns or spines; the heads are small, globose, involucre of many small bracts and the florets are brown and perfect. Tabernaemontanus does not state that the name is original with him, but in a pamphlet, "Illustrated Description of Thistles" by von Mueller (37), Tabernaemontanus is given credit for the name.

Tournefort (55) in 1700 named the plant *Cirsium arvense*, the name now most used. Cirsium is from Cirsion, the Greek for thistle.

Carl von Linné (33) in 1753 named this thistle *Serratula arvensis* and described it as having lanceolate dentate leaves with spinose margin and having creeping roots.

In 1772 Johann Anton Scopoli (49), an Italian botanist, restored Tournefort's name, *Cirsium arvense*.

In 1777 Robson (45), an English botanist, referred the plant again to the genus Carduus, reviving the earlier name *Carduus arvensis*. He added to the earlier description, "leaves subdecurrent, thorny, smooth on the surface, flowers solitary, corolla naked, florets all hermaphrodite, receptacle pilose, down (pappus) sessile, peduncles tomentose."

In 1804 George Franz Hoffman (30), a German botanist published the name *Cnicus arvensis*. Lund and Rostrup (34) hold that Hoffman's Cnicus is the same as the genus Cirsium of earlier autho

A critical comparison of the characters of these five named genera as given in the manuals shows that the plant belongs in the genus *Cirsium*.

As the binomial is the standard nomenclature and as *arvense* is the only specific designation offered in the binomial nomenclature, the correct name for this plant is *Cirsium arvense*. But Tournefort should be cited as the author and not Linné. I therefore take the liberty of adopting *Cirsium arvense* Tourn.

THE PLANT

The following description is based on that given in manuals of Botany (9, 10, 24), supplemented by the author's observations.

Perennial by horizontally creeping, thickened, white or yellowish, branched roots, from which, at irregular intervals, erect cauline branches are produced, which, on emergence, become the

green leaf- and blossom-bearing plants. These aerial branches are annual or biennial to below the surface of the ground.

Stems green, somewhat striate, surface glabrous, sparsely white tomentose (interwoven hairs) or hirsute (with bristling hairs) on young vigorous shoots, normally from 30 cm. to 1 m.* (12 to 40 in.) tall and paniculately branched.

Leaves typically green on both sides, upper surface glabrous, shining or with a few short white hairs on the young leaves; under surface of mature leaves glabrous; young leaves, especially those of vigorous shoots, white tomentose beneath; shape lanceolate to oblanceolate; apex acute terminating in a spine; margin deeply lobed to bilobed, ruffled; lobes acute terminating in a spine with marginal spines or prickles to the base of the lobe; spines 5/8 cm.* long, more or less rigid, very sharp; base of leaf sessile, narrowly clasping or of large leaves of vigorous shoots decurrent for 5cm. The spiney decurrent leaf bases give the impression of a spiney stem.

Inflorescense cymose; heads of flowers sessile or peduncled, numerous, dioecious, 1 to 1.5 cm. broad, 1.5 to 2 cm. high. Involucre of numerous appressed bracts, closely imbricated in 12 to 18 series, the outer short ovate or ovate lanceolate unarmed or tipped with short weak spines or prickles and sparsely arachnoid on the back and margins; the inner bracts successively longer and narrower, nearly or quite glabrous, and with accuminate spineless tips. Corolla glabrous, reddish purple or rarely white, limb deeply five cleft, tube slender. Flowers very fragrant. Stamens 5, alternate with the corolla lobes, anthers united in a column (anthers in staminate florets sometimes free) and with short appendages at apex and base; carpels 2, united throughout, but at maturity the style of the carpellate florets becomes two lobed. A narrow band of very short hairs encircles the style just below the base of the lobes. Stigmatic surface is on inner face of style branches. Pappus white, becoming slightly tawny at maturity of akenes, in several series, plumose to below the middle, united at the base in a ring, deciduous. Akenes from 2 to 3.5 mm. long by .9 to 1.2 mm. broad at the thickest part; shape fusiform to concavo-convex dependent upon the position of the akene in the head. Those at the center are more or less strict and fusiform in shape. From the center to the margin of the disk they vary from fusiform through flexuous and

*The metric system is used in measurements because small dimensions can be given more accurately than in inches. The transfer from one system to the other is easily made for 25 millimeters (mm), 2.5 centimeters (cm.), equals 1 inch.

plano-convex to concavo-convex at the periphery (Fig. 1). In cross section the akenes are more or less bluntly 4-angled, depending upon their plumpness. Those at the periphery of the disk are frequently 3-angled. The apex is surrounded by a minute circular crown within which is a small projection, the base of the style; color light brown, surface more or less shining. Disk covered with hairs 1 to 1.5 cm. long, at first white, becoming tawny when akenes are ripe. Period of blooming June to October. The seeds begin to ripen in July.

Fig. 1.—Akenes of *Cirsium arvense* showing shape and relative size. Left to right from center to periphery.

RECOGNITION MARKS

The Canada thistle is readily distinguished from all other thistles by its deep green, intensely spiney leaves, small heads of flowers borne in clusters, by growing in patches, and by its horizontal branching root.

DIOECIOUSNESS

The Canada thistle has the reputation of producing but few perfect seeds. This in the southern limit of its range is probably due in part to climatic conditions. However, throughout its northern range many heads fail to produce normal seeds or the heads may have one or but few seeds. This has long been known to be due to the fact that only certain florets are capable of producing seeds, that the flowers are dioecious.

A survey of the literature reveals a difference of opinion as to the completeness and extent of the dioeciousness, whether the florets are strictly monosporangiate, whether this condition is confined to the florets or to the heads or extends to the entire plant.

Robson (45) says "*florets* all *hermaphrodite*" (perfect).

Von Mueller (37) says "The perennial thistle is easily recognized - - - by having *staminate* and *pistillate* flowers perfected only on distinct *plants*, and these not always intermixed. Headlets of flowers of two forms, those with perfectly polliniferous anthers on individual plants distinct from those producing fertile seeds and larger, with more exerted flowers male (staminate) involucre more semiglobular; female (carpellate) involucre more truncate ovate." He notes also that this plant "less copiously produces seeds fit to germinate," than other thistles. His statements are supplemented by drawing showing in detail the differences between the staminate and carpellate plants.

Hillman (28) says, "Its - - - *flowers* are dioecious; that is certain *plants* produce only staminate flowers which do not produce seeds."

Porter (42) states without comment that the *plant* is dioecious.

Rydberg (48) makes the dioeciousness of the *flowers* the mark of distinction, without comment on the heads or plants.

Gray (24) says, "*heads imperfectly* dioecious."

Beal (8), "each seed as it grows *usually* produces a male *plant* or a female *plant.*

Britton (9) states in the key to the genus that the *flowers* are dioecious, and in the description distinguishes between the staminate and carpellate heads.

Cox (16), "this weed is peculiar in that only a few of the *plants* produce seeds which are able to grow. It is not known just what the conditions are which govern this."

Coe (14), "this *plant* is dioecious."

Hansen (26), "the *imperfect*-flowered and *perfect*-flowered *plants* are distinct; seed of course being formed on the perfect-flowered plants only."

This introduces a new feature, that of perfect flowers which have both functional stamens and carpels (bisporangiate) and are the only ones which produce seeds. Imperfect (monosporangiate) flowers may have perfect stamens or perfect carpels. The latter are also capable of producing seed.

Robbins and Boyack (44), "Canada thistles may be distinguished from other thistles - - - by the production of pollen and seeds in separate *heads.*"

Stevens (51), "the *flowers* are of two sorts, male on some *plants,* female on others."

Pammel (39), "*flowers* purple, dioecious."

Darlington (17), "*Florets* - - - *perfect* or the *heads* dioecious by abortion." He does not state to what the abortion is due nor whether the case is habitual.

Gress (25), "Some *plants* bear flowers *without pistils.* These of course never produce seeds." "The seeds are borne only on the *perfect* flowered *plants.*"

Hitchcock and Clothier (29) say that only a part of the *plants* bear fruit, but fail to suggest a reason.

Pammel and King (40), writing concerning the variety integrifolium, state that the *flowers* are *imperfectly* dioecious.

Coulter and Nelson (15) state that the *heads* are dioecious.

Britton and Brown (10) state that the *heads* are dioecious and distinguish between the staminate and carpellate. In the key to the genus, however, the statement occurs that the *heads* are *partly* dioecious.

Duysen (19) says the *heads* are dioecious.

Morse and Palmer (36), "Male and female flowers *usually* occurring on separate plants.

Petry (41) says the heads "are *nearly* dioecious, that is the heads of one plant - - - will have nearly all staminate flowers while other plants from another seed will have only pistillate flowers with few stamens." According to Petry, the number of stamens may be reduced.

Bull (11), "Some are only 'male' *flowers,* others only '*female*'. Some patches are said to bear only male flowers showing that all *plants* have come from a single seed."

Stone (52), "from *each* flower comes a small seed-like fruit."

Lund and Rostrup (34), "*Cirsium arvense* is dioecious." Well drawn figures show not only the differences between the size, shape, and structure, but also the manner of development of the florets and constituent organs. The authors also note a difference in the number of heads and florets in a head of the carpellate and staminate plants. They examined a large number of plants and found 690 the maximum, with 80 as the average, number of heads on the carpellate plants, whereas the number of heads on staminate plants was much less but they did not record the number. Moreover, the carpellate heads averaged 120 florets as compared with an average of 110 florets in staminate heads. The fragrance of the carpellate and staminate heads, they state, differs also. The perfume of the carpellate florets is stronger and similar to vanilla, while that of the staminate resembles the odor of the rust fungus *Puccinia suaveolens.*

To settle this question a survey was made of thistles from various sources in the State. Two distinct types of heads and florets were found. In the one that was clearly staminate the heads were oblong; corollas long; stamens long, exerted, tips of anthers on a level with or slightly beyond the tips of the corolla lobes; anthers fully developed; pollen abundant, mature, and being shed at time of opening of corolla; styles short, branches not separated, stigmatic surface not developed; pappus shorter than the florets and not in evidence in florets out of bloom; akenes formed but soon beginning to shrivel (Fig. 2, A).

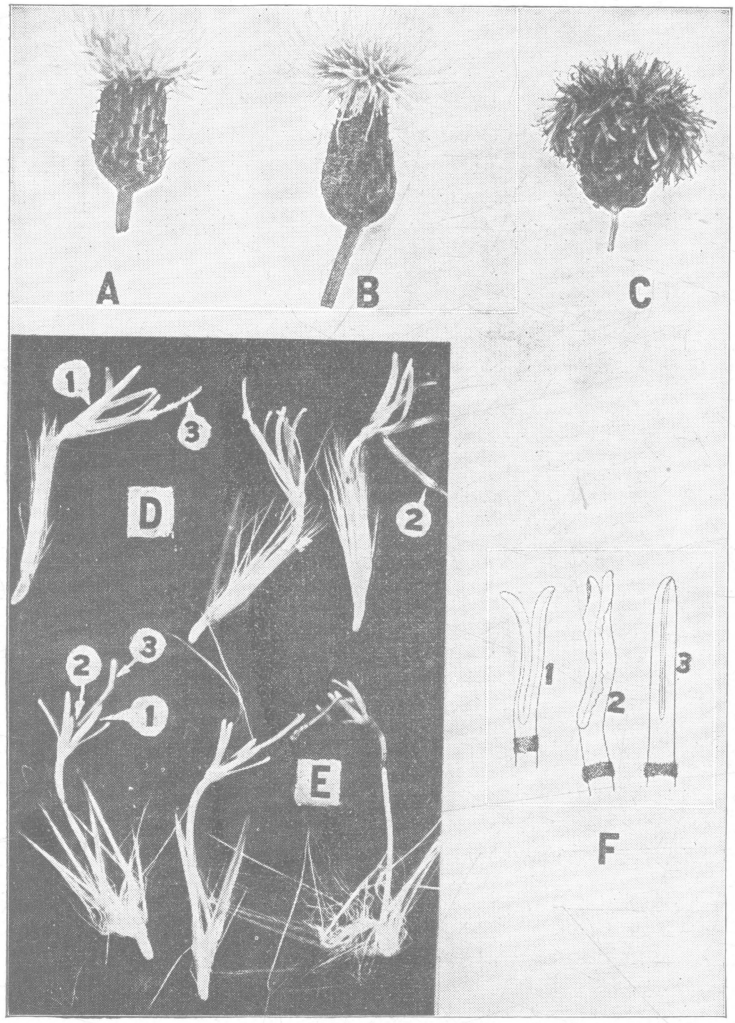

Fig. 2.—Dioeciousness of *Cirsium arvense*

A.—Staminate head in full bloom.
B.—Carpellate head in full bloom.
C.—Staminate head out of bloom. Pappus scarcely visible.
D.—Staminate florets.
1. Corolla with long lobes.
2. Stamens with long anthers producing abundant pollen.
3. Carpel, relatively short. Style lobes appressed. Pollen not on stigma.

E.—Carpellate florets.
1. Corolla with short lobes.
2. Stamens with short, blackened sterile anthers.
3. Carpel relatively long, style branches separating.

F.—Styles (after Lund and Rostrup).
1. Style of carpellate floret, branches diverging.
2. Style of carpellate floret showing stigmatic surface.
3. Style of staminate floret branches appressed.

Carpellate heads ovoid or flask shaped; corolla short; stamens short and more or less free, shriveled and blackened at opening of corollas; pollen none. Style long exerted, style branches diverging; stigmatic surface on inner face and exposed; no pollen in evidence on the stigmatic surface before opening of corollas; pappus long; akenes normal (Fig. 2, B).

Apparently, the segregation of staminatenous and carpellatenous resides in the plant. In the field, due to the ramifications of the propagating roots, it is practically impossible to determine how much may be one plant. Resort was therefore had to seedlings. Seed was sown in flats in the greenhouse, November, 1925. The seedlings were transplanted, one to a crock. They commenced blooming in July, 1926. All of the flowers of one plant were either staminate or carpellate, indicating that the *plants* are dioecious. An entire patch may be staminate or carpellate, thus accounting for the failure of seed production in some places, for staminate and carpellate plants must be near enough to insure pollination. Furthermore, as each floret must be pollinated the number of seeds in a carpellate head may vary from none to the entire number of florets.

VARIATIONS FROM THE TYPE

In some dense growths of Canada thistles there is pronounced variation; in others, and these are the more frequent, there is a close conformity to the type. The former indicates that many of the plants are seedlings.

Four distinct varieties of *Cirsium arvense* have been described by Wimmer and Grabowski (56). The following is a free translation of their description of these varieties.

(a) **horridum.** All leaves undulate (ruffled) pinnately lobed, lobes very narrow, strongly spinose.

(b) **mite.** Stem leaves sinuate-pinnatifid subundulate (less ruffled) branch leaves subentire or dentate, minutely spinose.

(c) **integrifolium.** All leaves smooth, obovate, lanceolate, margin entire, setose spinulose; undersurface glabrous.

(d) **vestitum.** Leaves denticulate, under surface white tomentose (with white matted hairs), peduncles lanate (covered with white wool like hairs.)

Varieties mite, integrifolium, and vestitum are reported as occurring locally in Quebec and the United States from the New England states to Iowa (26, 40).

In Ohio plants which have been identified as varieties vestitum, integrifolium, and mite, have been received from the counties of

Cuyahoga, Auglaize, Huron, Hancock, Wyandot, Hardin, Marion, Morrow, Logan, Union, Miami, and Butler; and in some cases reported as being more abundant than the species.

The distinctions between these varieties are based wholly on the leaves, the most variable of plant organs.

To determine the stability of these varieties, seed was collected during the summer of 1925 of the variety *vestitum* growing in abundance in a vineyard at North Olmsted, Ohio. Seed of but this one variety was tested as it was the only one available. The seed was sown in a flat in the greenhouse November 10, 1925, and January 9, 1926. The seedlings were several times transferred to successively large flower pots until the final transfer to 8-inch pots in which they were left and placed out doors.

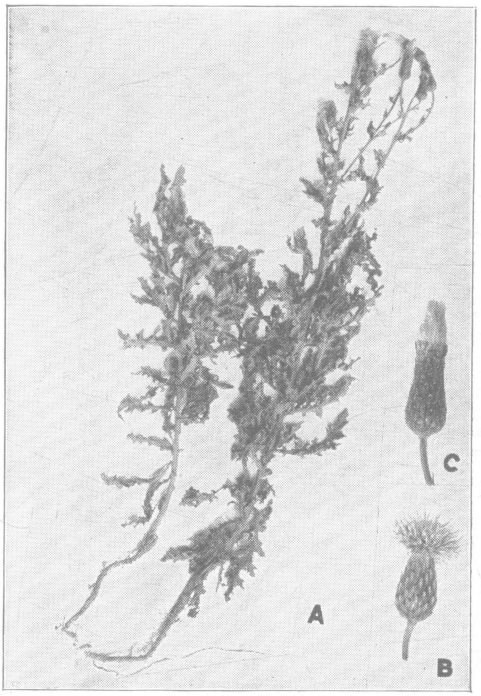

Fig. 3.—*Cirsium arvense* **Tourn.**

A. Carpellate plant.
B. Carpellate head in bloom.
C. Carpellate head just out of bloom.

The 103 plants which survived and grew thruout the summer showed remarkable variations in habit of growth from a few tall erect shoots branching freely and with well developed flower buds June 28, 1926, eight months from the seed, to numerous (5-18 shoots) unbranched and not developing flowers during the first growing season. Stem characters, freely branching to unbranched, glabrous surface to hirsute, distinctly purple in color to green. The leaves showed the greatest variation—in shape, from prevailingly oblanceolate to lanceolate; in size, from 2.5 cm. long by 1 cm. wide to 22.5 cm. long by 8.75 cm. wide; in margin, from almost entire spinulose to deeply bilobed, ruffled and armed with sharp, stiff spines; surface smooth and shining to clothed with short hairs on the upper surface and glabrous to densely white

tomentose on the lower; base sessile to decurrent for 5 cm. Even the color of the leaves varied from a deep bluish to a light yellowish-green.

Every variety reported as occurring in the United States was represented in these seedlings (Fig. 5). There were also plants typical of the species (Fig. 5, D). All seedlings were perennial from vigorously growing, branching, shoot-producing, propagating roots. This character was constant. All plants that bloomed also agreed in the cymose branched type of inflorescense in small heads and in the dioeciousness of the plants.

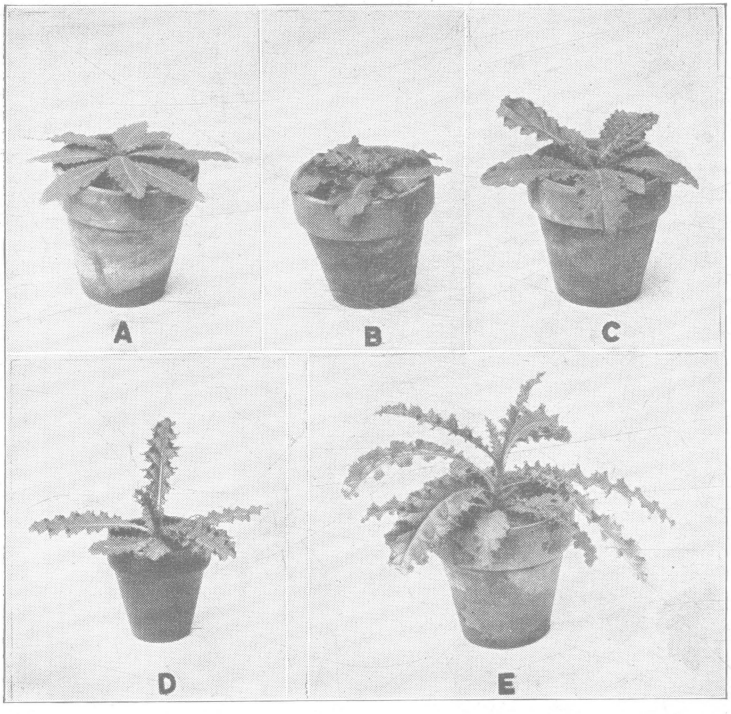

Fig. 4.—*Cirsium arvense* var *vestitum* 5 months old seedlings showing segregation of leaf and stem characters

A, B, and C are most similar to var. *vestitum*.
D and E closely resemble the species.

As a check, seedlings were grown from the species under the same conditions. All of these were true to type.

From the results of this experiment it is evident that the variety vestitum and undoubtedly the other varieties as well are hybrids with paired unlike stem and leaf characters which freely

Fig. 5.—*Cirsium arvense* **var.** *vestitum* **Wimm. & Grab.**

A. (1) Upper portion of a vigorous mature aerial shoot, (2) Carpellate head in bloom, (3) Carpellate head with mature akenes.
B. Seedling, 9 months old, closely resembling var. *vestitum*.
C. This segregation, 9 months old, from the type closely resembles var. *integrifolium* Wimm. & Grab.
D. This segregation, 9 months old, would readily be taken for a normal *Cirsium arvense* with strongly decurrent leaf bases.

segregate. The parents of the particular plant from which the seed was taken must have been two forms or variations of *Cirsium arvense* or one of these and the species, each parent evidently having both pairs of the perennial propagating root and dioecious floret characters.

Cirsium arvense is credited with hybridizing quite freely. The literature contains references to several variations assumed to be hybrids, e. g., *Cirsium celakowskyanum* Knaf. (47) = *(C. arvense* x *palustre); Cirsium Durrenbergeri* Khek. (32) = *(C. arvense* (L) Scop. x *C. erisithales* Scop.); *Cirsium eliasii* Sennen et Pau (20) = *(C. flavispina* x *arvense); Cirsium discolor* (22) = *(C. heterophyllum* x *arvense); Cirsium sextenum* (4) = *(C. acaule* x *arvense).*

Lund and Rostrup (34) found great variation among plants grown from seed. To quote from their monograph, "Our experiments have demonstrated that in sowing seed from one and the same form we obtained a large number of diverse seedlings, with but a restricted number which reproduced the mother plant or which showed resemblance among themselves. The number of forms is immense, but, if by forms one understands only those which present particularly distinctive characters which are sufficiently pronounced and which occur only in a definite habitat only, the four following can merit the name: *Cirsium arvense* form maritima, f. setosa, f. argentea and f. gracilis." According to the authors each of these forms is found in a definite habitat, e. g., form maritima occurs in Marsh land and is characterized by short, strong, often thickened stems; sessile, deeply pinnatifid leaves with closely set and strong thorns, by an open branching system and large heads clustered at the ends of the branches. Form setosa grows in shady places under trees and is distinguished by dentate leaves with small weak spines, base sessile or decurrent, surface green and glabrous on both sides, or pubescent, especially beneath; heads few and often entirely sterile. This form readily reverts to the typical or more usual one when exposed to ample light.

Form argentea occurs in pastures, open grassy woods and grass grown roads. It is distinguished by the dense covering of snow white hairs on the under side of leaves and on the long peduncles; heads few, small, and often sterile.

Form gracilis can be recognized by its tall, slender build, its small cylindrical heads and small conical tapering akenes but half as large as of the species.

These forms seem to be temporary, their distinctiveness being conditioned by their environment. Change this and they lose these distinguishing characters.

CONDITIONS OF GROWTH

Contrary to the popular belief that weeds will grow anywhere, they are influenced by their environment just as are crop plants. The Canada thistle is no exception. It will thrive, barely hold its own, or succumb, dependent upon soil, water, light, and temperature conditions. In nature the influence exerted is always through a combination of all four factors; but experimentally under controlled conditions it was possible to limit the major influence to one factor. Each of these factors will be briefly discussed.

Soil.—The most pronounced influence of the soil is exerted on the root system. Clay soil is the most favorable to root development. The greatest length attained by a propagating root was 4½ meters. In sand and gravel the greatest length attained was 1 meter, in muck 3¾ meters, and in limestone soil 1¾ meters.

Moisture.—That which is characteristic of mesophytic conditions is most favorable to root and shoot development. This is also the condition most favorable to crop plants.

Light.—Canada thistles are intolerant of deep shade and though they abound in wood lots, if at all shaded they are tall, lax, and produce but few blossoms and at a later date than in full light. This intolerance to shade is a weakness of which advantage may be taken in control measures.

Temperature.—They are distinctly northern plants. In the United States temperature conditions between the 40° and 49° north latitude are most favorable to the plant's development.

The most favorable environment therefore for the development of Canada thistles is provided by an upland region of unshaded clay soil with sufficient moisture to support a good stand of blue grass, wheat, or corn and with a seasonal temperature range of 90° F. maximum to about 32° minimum. Below this the aerial shoots are frozen.

PRODUCTION AND VIABILITY OF SEED

The production of Canada thistle seed is limited and uncertain, being dependent on the presence of both staminate and carpellate plants near enough to insure pollination and, to a certain extent, upon climate. Moreover, often not more than half of the blossom head buds formed reach maturity. Other factors which will be discussed later also affect the yield.

To determine the probabilities of seed production a count was made of 300 well-developed carpellate heads. They averaged 75 florets to the head. One vigorous, freely blooming shoot may, throughout the blooming season, produce 100 heads. So that under favorable conditions a shoot may produce 7500 seeds. The actual yield falls far below this.

Hansen (26) states that north of Pennsylvania, Canada thistles are disseminated widely by seeds and that if the southern boundary of Michigan were continued as a line east and west it would constitute approximately the boundary south of which viable seed is rarely found. This statement is too sweeping as there is abundant evidence of dissemination through seed in Ohio. Moreover, normal seeds produced in North Olmsted showed a range of viability of 4 to 48 percent in recent germination tests conducted during the autumn and winter, beginning September 11 of the same year the seeds ripened. They were sown on moist blotters in a germinator kept at room temperature and in flats of soil in the greenhouse.

Dorph-Peterson (18) found in Denmark 88 percent of the seed germinated the first spring following its production.

Viability.—Tests were conducted over a period of years by Duvel and Goss (23) of the seed testing laboratory of the United States Department of Agriculture to determine how long buried weed seeds retain their viability. Of especial interest in their tests is the record of buried Canada thistle seeds. The following extract is taken from their report.

"The seeds were mixed with sterilized soil taken from the pit where the seeds were to be buried. The mixture of seed and soil was placed in common flower pots. These pots, each covered with a porous saucer, were . . . buried in the soil at Arlington Experiment Station, Rosslyn, Va. The soil in the pots was found to resemble in texture and moisture content the earth surrounding them.

"Two sets of pots of each of the three sets of seeds were buried at different depths. A pot of seeds of each set was dug up at stated intervals and the germination of the contained seeds immediately tested in the greenhouse." The table on page 17 gives the record of the Canada thistle seeds.

It is noteworthy that the vitality of the seeds was retained to the greatest degree at the greatest depth. Five to eight inches is the depth of plowing in ordinary practice. Seeds on the surface could readily be buried to this depth during plowing, and, in some

crop rotations, might remain undisturned for a number of years, to be again brought to the surface and to conditions of germination. Sudden outbreaks of these plants may be accounted for in this way.

TABLE 1.—Viability of Canada Thistle Seeds, Arlington Experiment Station

Seed set	Depth planted	Seeds	Percentage germinated, dates exhumed					
			1903	1905	1908	1912	1918	1923
	In	*No.*	*Pct.*	*Pct*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
A	8	200	21 0	35 0	14.5	5 5	3.0	0.5
B	22	200	22 5	28.5	15 5	9 5	0 5	0.5
C	42	200	28.5	38.5	25 5	2.0	3 0	4.5

PROPAGATION AND DISSEMINATION

Canada thistles have two means of propagation by which they perpetuate themselves from year to year and are also disseminated.

There is a complex root system, consisting of the ordinary fibrous absorbing organs and horizontally creeping branching thickened roots which are organs of storage and propagation. The latter may be at a depth of a few inches to two and one-half feet below the surface. In grass lands they lie beneath the sod and are consequently not disturbed when the sod is broken. In cultivated ground they usually are at a greater depth than that reached in ordinary plowing.

These roots continue each growing season to elongate, branch, and store food. The branches are of three kinds—absorbing, storage, and propagating roots and stems which grow upward towards the surface and, on exposure to light, become the green leaf- and blossom-bearing aerial shoots. Root development begins early and progresses rapidly. A four months old seedling from seed sown in January in the greenhouse and growing in a 7.5 cm. (3 in.) pot was examined and photographed in April. It then had a root 101 cm. (40 in.) long, which bore 19 leaf buds one of which had reached the surface forming a small shoot. Another more vigorous seedling of the same age and grown under identical conditions, had a thicker root with 10 leaf buds, 4 of which had already reached the surface.

Under field conditions Canada thistles bloom and seed the second season from the seed. Some of those started from seed sown in November and January in the greenhouse, transferred to pots, and in June placed out of doors, were blooming in July, 8 and 6

months from the seed. Aerial shoots from propagating roots and from the subterranean portions of stems appearing above ground from April to June or even July, will bloom the same season, the later ones will not bloom until the following season. All shoots, after seeding, die at the end of the season. Consequently, the early ones are annual. The later shoots, under favorable winter conditions, remain alive until the next growing season, flower, seed, and then die down to the root and consequently may be considered winter annuals or biennials.

The seeds may germinate during late summer and fall, and the resulting seedlings winter over, becoming thus winter annuals.

The seeds are attached to a tuft of fine plumose hairs, known as the pappus, by means of which, as by a parachute, they are borne by wind and water currents. They are also borne by the hairs of animals and the clothing of people. Threshing machines serve to carry seed from farm to farm. In hay and straw used as fodder or bedding of animals or as packing, seeds may be transported long distances by train and ship. Introduced weeds often occur first along railroad tracks, on circus ground, at ship docks. A striking illustration of transportation in ships is presented by the report in 1893 of a patch of Canada thistles on heaps near the docks at Mobile, Alabama (35). These migrants, far removed from their usual habitat, are thought to have been brought there in the waste of a ship. The seeds are also disseminated as an impurity in crop seeds.

INTRODUCTION AND DISTRIBUTION

The common or popular name in America, Canada thistle, has given rise to the misconception that this thistle is a native of Canada. All authorities, however, agree that it is indigenous to Europe, Western Asia, and Northern Africa, and that Europe is the source of dissemination to Australia and North America.

According to Hansen (26), the plant was early introduced from Europe into the Provinces of Quebec and Ontario as an impurity in seed. It was introduced into the New England States and New York at about the same time. Although the exact date of introduction into New England is unknown, it was prior to 1795 as, in that year, it was officially recognized by law in Vermont. In New York it was not outlawed until 1813. Baled hay brought from the north to Virginia for the horses of the Union army during the civil war is said by Hansen to be the source of this thistle in

Fauquier County, Virginia, at about that time. According to the same author it was not reported west of the Allegheny mountains before 1835.

Although not recorded in any lists or catalogs of Ohio plants prior to Newberry's (38) catalog, published in 1859, in which its location is "the lake shore", it must have been sufficiently abundant in Ohio or on its borders to be considered a pest at least 15 years earlier, for on March 6, 1844, the legislature of Ohio enacted a law "To prevent the introduction and spreading of the Canada thistle." It is not known whether it came to Ohio from Canada or the eastern states.

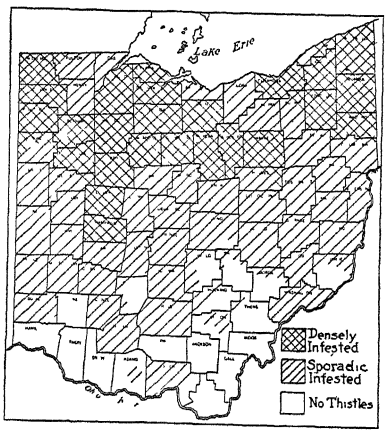

Fig. 6.—Distribution of *Cirsium arvense* and varieties in Ohio in 1926

In 20 years (31) it had spread freely throughout the northern and central counties of the State. Its present distribution in Ohio is shown on the map, Figure 6.

Its present distribution in the United States is indicated in Figure 7. The heavy sinuous black line traces its southern limit. The location at Mobile, Alabama, is omitted because these thistles have probably disappeared.

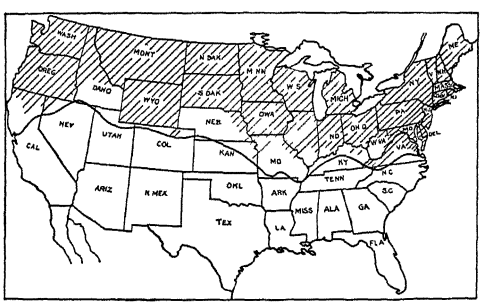

Fig. 7.—Distribution of *Cirsium arvense* and varieties in the United States in 1926

WHY CONSIDERED NOXIOUS

The deep-seated, creeping, branching root system stored with an abundance of food not only insures perennial life to the plant, but permits it to form dense masses of aerial shoots which crowd out other vegetation, and to spread indefinitely not only from year to year but from day to day (Fig. 8). The depth to which the propagating roots penetrate insures escape from destruction by plow and cultivator. The case with which the seeds

are disseminated and their longevity increase the difficulties of control. The spiney leaves ordinarily protect it from grazing animals. It is these features which make extermination difficult and entitle the plant to be considered noxious.

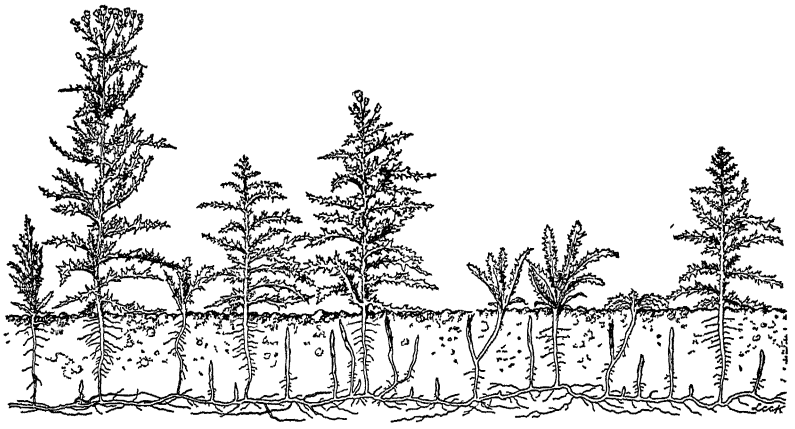

Fig. 8.—Diagrammatic sketch representing branching root system and development of aerial shoots. Courtesy of U. S. Dept. of Agriculture

USES

The adage that nothing is as black as its enemies paint it holds also in this case. The Canada thistle and its varieties are wonderfully fragrant and very attractive to honey bees. It may therefore be listed as a honey plant. Apparently, the plant has some slight medicinal value as the Eclectic School of Medicine uses the root. The young shoots are said in Europe to be eagerly eaten by all grazing animals (37). This does not seem to prevail in Ohio.

ENEMIES, PLANT AND ANIMAL

Fungi.—Canada thistles are quite free from parasitic fungi. The only ones found in Ohio, in this study, are *Septoria cirsii* Niesl, which causes a leaf-spot disease; and the rust, *Puccinia suaveolens* (Pers.) Rostr.

The spots caused by *Septoria cirsii* appear on the thistle leaves about mid summer and continue to develop until October. The spots are amphigenous, large, dry, indefinitely circular, light brown with a darker brown border. The perithecia are gregarious, minute, and hemispherical. The spores are hyaline, cylindrical, subflexuous, obtuse at both ends, 8-12 septate, 40-80 microns long

by 1.5-2 microns thick. Infested leaves eventually become wholly brown and dry. The disease is common in Ohio and abundant in some localities; but as the infection develops first in the lower leaves, gradually spreading upward, and as it does not appear until vegetative maturity has been attained, the growth of the host is checked but little or not at all.

Puccinia suaveolens Pers. occurs sporadically in Ohio. It was found at the Experiment Station and near Sycamore, Wyandot County. It is reported in North America from Nova Scotia to Rhode Island and New Jersey and as far west as Utah. Its life history and effect on the host, as given by Rostrup (46), are as follows:

> The mycelium invades the whole plant and hibernates in the upper part of the root-stocks, so that every shoot sent up by this root contains the mycelium. The affected plants appear sooner than the healthy ones, have a sickly pale-green color and do not bear flowers. The fungus has two generations, the first is the perennial one and produces pycnia and primary uredospores. The second attacks leaves and shoots only, and is annual.

Under the name *Bullaria suaveolens* (Pers.) Arth., Arthur (1) describes the fruiting of this rust as follows:

> Pycnia hypophyllous or epicostal and caulicolous, scattered evenly over large areas preceding or accompanying the primary uredinia, conspicuous, punctiform, globoid or somewhat conic, 90-185 microns broad, two-thirds as high; pycniospores elliptic, 1 by 3 microns.
>
> Uredinia of the primary form hypophyllous and caulicolous, round, 0.3—0.5 mm. across, scattered evenly over large areas, often confluent, early naked, pulverulent, chestnut-brown, ruptured epidermis conspicuous; uredinia of the secondary form scattered or gregarious; urediniospores globoid or broadly ellipsoid, 22-26 by 24-28 microns; wall thin, 1-1.5 microns, cinnamon-brown, closely and minutely echinulate, the pores 3, equatorial.
>
> Telia hypophyllous and caulicolous, round, 0.3—0.5 mm. across, evenly scattered over large areas or somewhat gregarious, coalescing, or occasionally irregularly scattered, early naked, pulverulent, chestnut-brown, ruptured epidermis conspicuous; teliospores ellipsoid, 20-24 by 30-28 microns, rounded at both ends, slightly constricted at septum; wall light chestnut-brown, uniformly thin, 1.5-2 microns, closely and finely verrucose, the pore of lower cell half way between septum and base; pedicel colorless, fragile, short.

In Ohio no large areas of infection were found, indicating that the fungus spreads but slowly. Moreover, rust-infected plants were in blossom and, though in one case wilted, did not suffer much damage from the fungus.

Bacteria.—In a thistle infested wood lot near Sycamore, Wyandot County, a number of stunted, dead, and dry Canada thistles were found. Specimens were collected and cultured. A bacterium

was isolated from the cultures. Inoculation experiments were started. Although the work is still incomplete, there are indications that the bacterium is the causal organism.

Birds.—The American Gold Finch, or Wild Canary, *Astragalinus tristis tristis* L., also sometimes called the Thistle bird, destroys a large number of thistle seeds. Fortunately, it is one of our common birds of the fields and meadows.

Insects.—A number of insects have been collected in Ohio on Canada thistles. The most conspicuous is the Painted Lady butterfly, *Pyrameis cardui* L. (Fig. 9). During the summer of 1924 unusual numbers of this insect occurred throughout northern and western Ohio, resulting in extensive defoliation of the food plant. According to Dr. C. R. Cutright, department of entomology, of the Ohio Agricultural Experiment Station between June 20 and July 10 many larvae were sent from northwestern Ohio to the Station. In some localities the larvae of the first brood stripped the thistles of all leaves and uninfested plants could scarcely be found. Fresh shoots appeared during the latter part of July and later; and the second brood of larvae was almost a failure. Consequently, but little permanent damage was done.

The insect was even more abundant in Michigan in 1923-24. Prof. R. H. Pettit, department of entomology, Michigan Agricultural Experiment Station, reported an outbreak of the Painted Lady on Canada thistles in oat fields during late June, 1924, which surpassed all previous records in Michigan. "The larvae also devoured Burdock and sometimes Nettles and occasionally Plantain and Elm; but in no case molested valuable crops. When starved to it mint and soybeans were accepted as food. However, whenever they discovered thistles, the mint and soybeans were abandoned for the more choice thistles." In places the number of caterpillars "literally covered the ground behaving much like army-worms in their search for food."

The insect is striking in appearance and easily recognized.

The imago butterfly is of medium size, length of body and head exclusive of antennae 1.8-2.2 cm.; wing spread 5.9-7.7 cm. Seen from above it is yellow or orange with brown or black and a few pale yellow or white wing markings.

The larva or caterpillar when mature is 30 mm. long; the head is black or reddish black with long, white hairs from wart-like papillae and has a dull yellow band down the front; the body is grayish-brown variegated with yellow and velvety black, thickly sprinkled with fine whitish hairs and has a pale yellowish broken

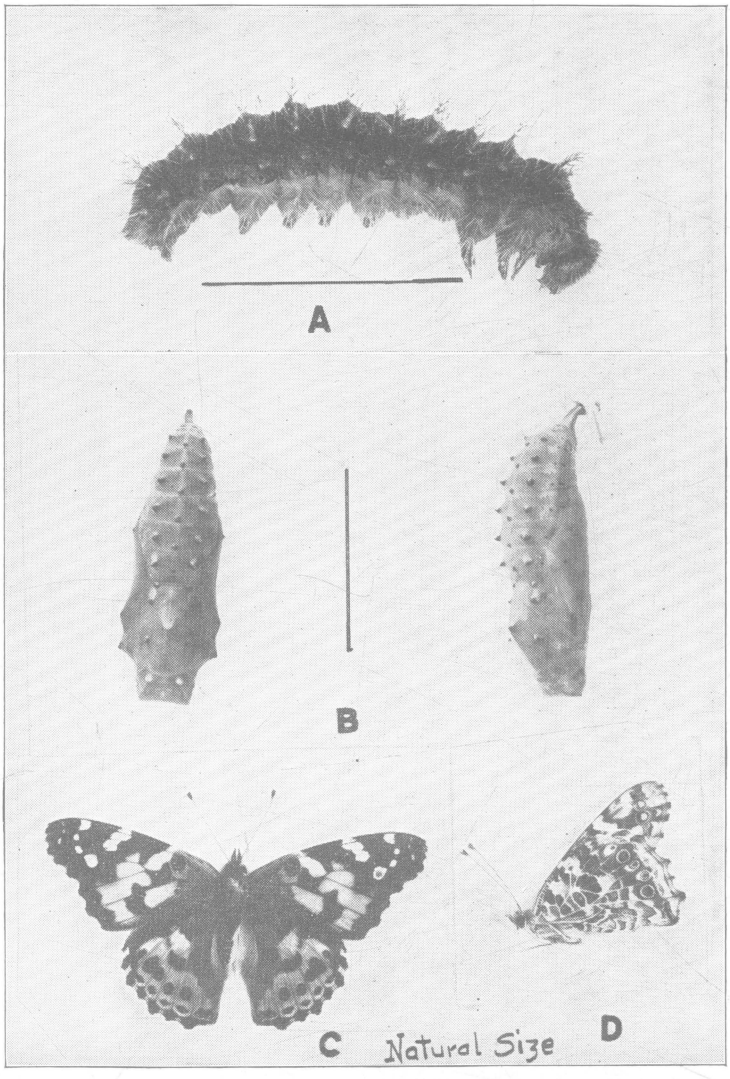

Fig. 9.—*Pyramiis cardui* **L. (Vanessa cardui) Painted Lady Butterfly**

A. Larva.
B. Pupa, dorsal and lateral aspects and mode of attachment.
C. Mature butterfly from above.
D. Mature butterfly showing wings from beneath.

stripe on each side close to the under surface. Every segment except 1 and 2 bears tufts of spines (Fig. 9, A). The larva pupates during the latter part of June or early July. The chrysalis usually hangs suspended from some part of the food plant.

The pupa is from 20.5-23 mm. long and from 7.25-7.5 mm. at its greatest width, in color golden or greenish yellow with pearly luster and with two parallel longitudinal rows of tubercles tipped with gold. Small black dots or small tubercles occur in rows between the larger tubercles (Fig. 9, B). In about a week or ten days the butterfly emerges and soon lays the eggs of the second brood or, if it is of the second brood, winters over in the butterfly stage and lays its eggs the following May.

But few Painted Ladies were seen during the summer of 1925. They were somewhat more numerous during 1926, but had little effect on the food plants. Other food plants of this insect are the bull thistle, burdock, nettles, garden hollyhock, and sometimes plantain and elm.

An instance of an insect ordinarily attacking crop plants but preferring thistles was furnished at Bono, Ohio, the head quarters of the Ohio Experiment Station European Corn Borer investigations in 1926. The sod-web worm, *Crampus* sp. was found infesting sweet corn. In one plot 600 hills were reduced to 70 by the worms. Dr. L. L. Huber, of the department of entomology, Ohio Agricultural Experiment Station, found in one worm-infested field, with Canada thistles among the corn, that thistles were preferred to corn. The larvae girdled the stems of the thistles at 1 or 2 inches below the surface of the ground. But little corn in this field was attacked.

Dasyneura gibsoni Felt.—During a survey in 1924 to determine the extent of seed production by Canada thistles in Ohio, requests for thistle seed or heads were sent to farmers all over the State. A very frequent reply was that no seed could be found as the heads were "blasted". Examination of such heads disclosed the presence of a minute, orange-colored, footless grub, which was identified by Dr. E. P. Felt, State Entomologist of New York, as the larva of the Canada thistle midge, *Dasyneura gibsoni* Feft. Dr. Felt wrote that the midge had been received from Ontario and Indiana but that this was the first report of its presence in Ohio.

This insect is closely related and very similar in appearance and life history to the clover seed midge, *Dasyneura leguminicola* Lint, which materially damages the clover seed crop.

The mature larva of the thistle midge is a minute, 3 mm. long, orange-red, footless maggot, with sucking mouth parts (Fig. 10, D). A large number of larvae were collected and placed in breeding cages and although a number of these transformed to adults no cocoons nor pupae could be found. They, however, are probably very similar to those of the clover seed midge, of which the cocoon is oval, 2 mm. long and of silken threads. The pupa is

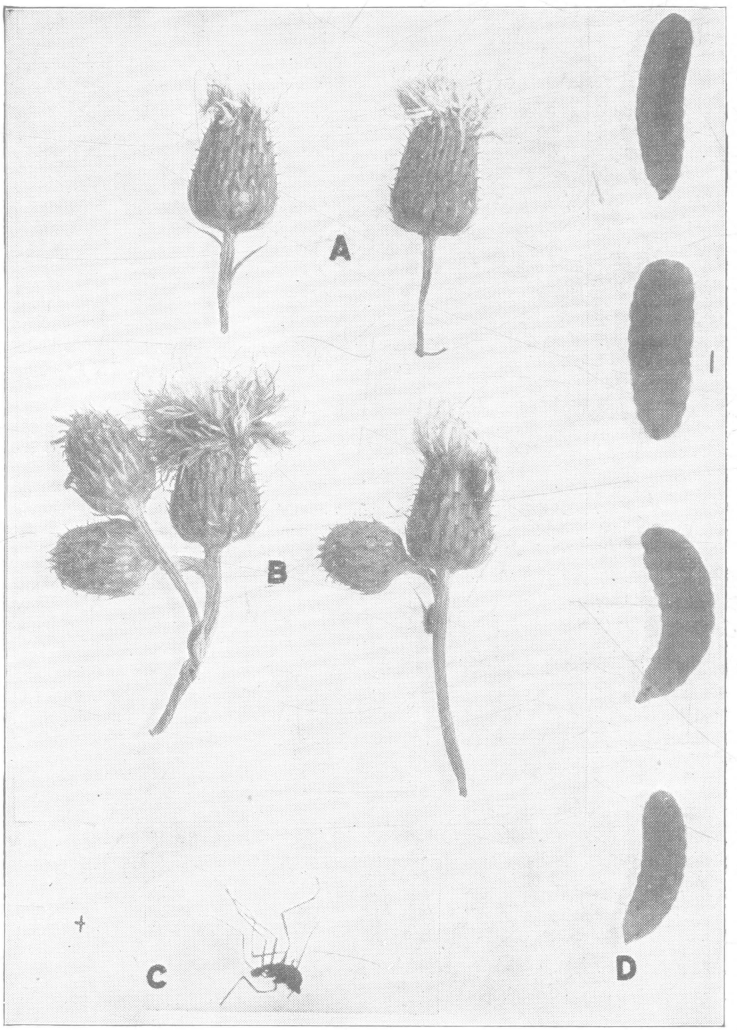

Fig. 10.—*Dasyneura gibsoni* **Felt., Canada thistle midge**

A.—Uninjured Canada thistle blossom heads. B.—Punctured by midge. C.—Adult midge. D.—Mature larvae.

pale orange with brown eyes and with a pair of short conical tubercles on the front of the head and a rather long horn near the base of each wing.

The thistle midge adult is a very minute two-winged fly, 1.25 mm. long, with wing expanse 2.5-3 mm., head dark reddish-brown, antennae long with 12 bead-like joints, thorax and abdomen dark orange, wings shining almost hyaline but with rose colored irridescence, legs 2 mm. long. Entire insect bristly with short blackish hairs (Fig. 10, C).

Life history.—The eggs are laid in young unopened thistle heads, through a puncture in the head near the top (Fig. 10, B). As some heads showing no external mark of entrance contained midge larvae, egg-laying may also take place in opening heads. The larvae from 1 to 12 in number were generally found near the base of the florets where they evidently suck the juices from the young akenes thereby preventing their developmnt. The pappus also was blackened and shriveled, giving the head a "blasted" appearance. At maturity, the larvae crawl up the floret, clinging to the pappus, to drop out of the head to the ground, where pupation probably takes place. The period of pupation in breeding cages was very short. From active larvae placed in the cage July 15, one fly emerged July 17, five by July 22, and a total of 25 by July 28. There are doubtless two broods during the summer, as young immature larvae were plantiful in yiung flower heads in August.

The insect infests both staminate and carpellate heads. No estimate could be made of the damage done, as the midge-infested carpellate heads had the appearance of non-pollinated carpellate heads which were also infested. Its range was general throughout Canada thistle areas in the State.

Trypeta florescentiae L.—A yellowish-white footless grub, 5 or 6 mm. long, was found in thistle heads at North Olmsted, Ohio, on July 27, 1925. From 1 to 4 larvae were found in a head, the usual number being 1 or 2. Later the larvae were also found in thistle heads on the Experiment Station grounds. Infested thistle heads were put in jars covered with cheese cloth and placed in a moist chamber July 29. By the last week in August, five adults had emerged. Two more appeared later. Dr. J. M. Aldrich, of the National Museum, Washington, D. C., identified the insect as *Trypeta florescentiae* L. (Fig. 11, A). No pupae were found. Pupation evidently takes place in the larval skin without rupturing it, for no pupal cases were found. But a number of empty ruptured larvae skins were found closely immeshed in the cocoon.

The adult is 5-6 mm. long with wing expanse of 6 mm., and strikingly marked. The head is a pale, yellowish-green, compound eyes vivid green, thorax dorsally black except a lighter marginal line and a wedge-shaped light spot at the posterior end. The entire thorax bristles with short, stiff, white hairs; there are 4 black bristles on the scutellum. The abdomen is covered with short white hairs and with two dorsal and two lateral lines of black spots. Wings pale gray with rosy irridescence and with three marginal and four other blackish spots on the veins, surrounded with a whitish border (Fig. 11, D).

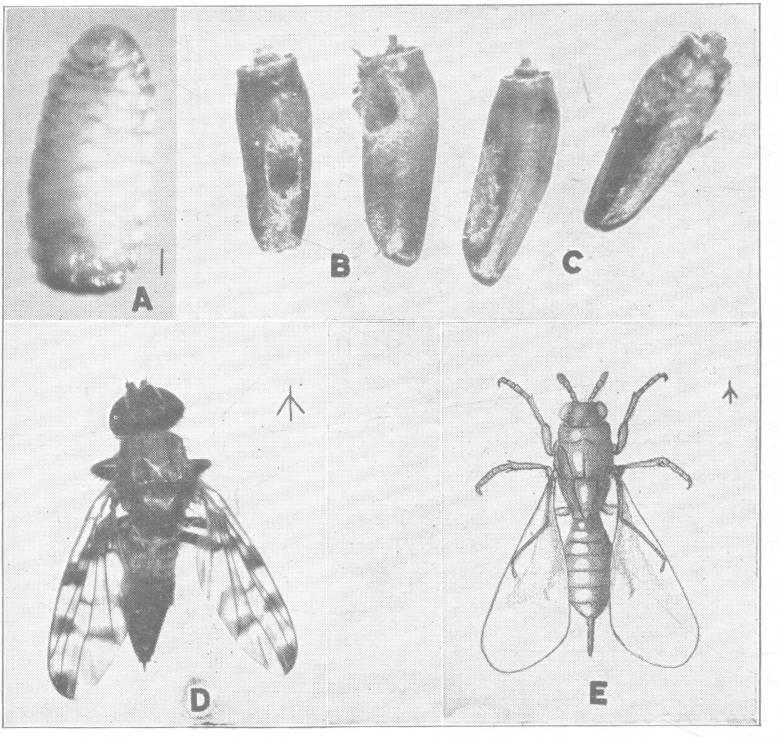

Fig. 11.—*Trypeta florescentiae* **L. and parasite** *Aprostocetus canadensis* **Ashmead**

A. Larva of *Trypeta florescentiae* L.
B. Akenes gnawed externally.
C. Empty shells of akenes. The seeds have been devoured and the larvae have crawled out.
D. Adult of *Trypeta florescentiae* L.
E. Adult of *Aprostocetus canadensis* Ashmead.

Life history.—Fully developed larvae were found July 27, 1925. The young larvae develop among the akenes and by eating through the pericarp from without gain entrance into the akenes (Fig. 11, C). After completely consuming the seed they crawl out and finally weave a cocoon of pappus hairs glued together by a substance secreted by the larva. The cocoon is imbedded in a shapeless tangle of pappus hairs loosely woven together. The insect hibernates in the larval stage in the thistle heads. The pupation period and number of broods was not determined. Larvae in infested heads placed in cheesecloth covered jars July 28, 1925, and kept on the laboratory table at room temperature, were found to be alive January 1, 1926. *Trypeta florescentiae* occurs also in Europe. Dr. Aldrich wrote that the fly had been reared from Canada thistles once or twice before. It had not, previous to 1925, been reported from Ohio. *Trypeta florescentiae* was less abundant in 1926 than in 1925. There were larvae-infested heads on the Station grounds; and quite a number of infested heads were found July 27 in a wood lot near Sycamore, Wyandot County. Lund and Rostrup (34) note the destructive infestation of Canada thistle heads in Europe by *Trypeta flava*. According to them the mating of the adults takes place in the latter part of June and they have seen the small yellow flies swarm over and settle on thistle heads in the latter part of June and throughout July. Furthermore, they say that infested thistle heads can easily be recognized by a rupture of the involucre on one side. The heads are often also somewhat twisted. Such ruptured heads were not uncommon in Ohio but no *Trypeta larvae* were found within them. On the contrary they were infested by midge larvae and the *Trypeta* larvae were found in heads wholly uninjured externally.

A search for pupae in infested thistle heads led to the discovery that the *Trypeta* larvae were severely parasitized by an *Hymenopterous* insect. Eight parasites were found in one larval skin. The parasite was identified by Dr. Aldrich as *Aprostocetus canadensis* Ashmead (2) (Fig. 11, E).

The parasite is a minute, 2-3 mm. long, shining dark greenish-blue, 4-winged fly with quite long honey yellow legs and hyaline wings with rose colored iridescence and covered with very short dark hairs, margins of wings ciliate. It was named and described by Ashmead. Very little is known concerning the life history of this parasite. As an internal parasite it passes its existence through the egg, larval, and pupal stages within the larvae of its host. It is of particular interest in the study of Canada thistles in

that it destroys an effective enemy of the thistle. The parasites were very numerous in 1925, and considerably less so in 1926.

Anuraphis cardui L., the long-beaked thistle aphis, is another insect of some economic importance. Its alternate food plant is the cultivated plum, on the leaves of which it is sometimes a pest. The aphid is greenish with a black spot on the middle of the abdomen.

Capitophorus carduinus Walker.—A second thistle aphis was collected on thistle leaves in 1924. The artichoke is one of its food plants.

Although two of the six insects mentioned do considerable damage to thistles during severe infestations, no dependence can be placed on the duration and recurrence of their attack.

CONTROL AND ERADICATION

Measures of control and eradication of any plant to be efficient and reliable must hold in subjection or completely overcome the plant's most resistant and virile characteristics. The Canada thistle's greatest resistance to antagonistic forces lies in the depth to which the horizontal propagating roots penetrate, a depth greater than that reached in ordinary plowing or sod breaking; in the large amount of reserve food in the propagating roots; in their facility to produce leaf buds quickly and abundantly; and in their diffuse branching system, permitting ramification in all directions. Thus, it can readily be seen that the root system can be killed directly only by means of difficult and extreme measures; and that the weed can be more easily exterminated through the death of the green shoots, for with these rendered inactive the roots must starve.

The methods discussed and recommended in this paper are, therefore, a complication of those gleaned from the literature, from letters from farmers and county agents, and from the author's experiments.

Control measures aim to keep the plant from spreading unduly either through seed or propagating roots. **Eradication** is the removal or killing of the entire plant. The following methods have been tested in actual practice.

Mowing is especially applicable to permanent grasslands. In order to be effective the first cutting must be while the thistles are quite small, and subsequent cuttings must follow at short enough intervals, one to two weeks is a common practice, not only to prevent seed formation but also to reduce as much as possible the

amount of food prepared by the leaves and green stems and thereby the amount of reserve food stored in the roots. This method, primarily of value as a control measure if repeated as often and as long as green shoots appear, will in time effect the death of the entire plant.

It is the method used by most farmers and is the one prescribed in the weed laws of Ohio.

Cropping by grazing animals has the same effect as mowing and is instrumental in the control rather than the eradication of thistles. In Europe all kinds of stock are said to eat young thistle shoots with avidity. This does not seem to be the case in Ohio; but if dry salt be scattered over the plants, stock will crop them to get the salt. Naturally cropping is less reliable than persistent and oft-repeated mowing as it is more irregular; but it is cheaper.

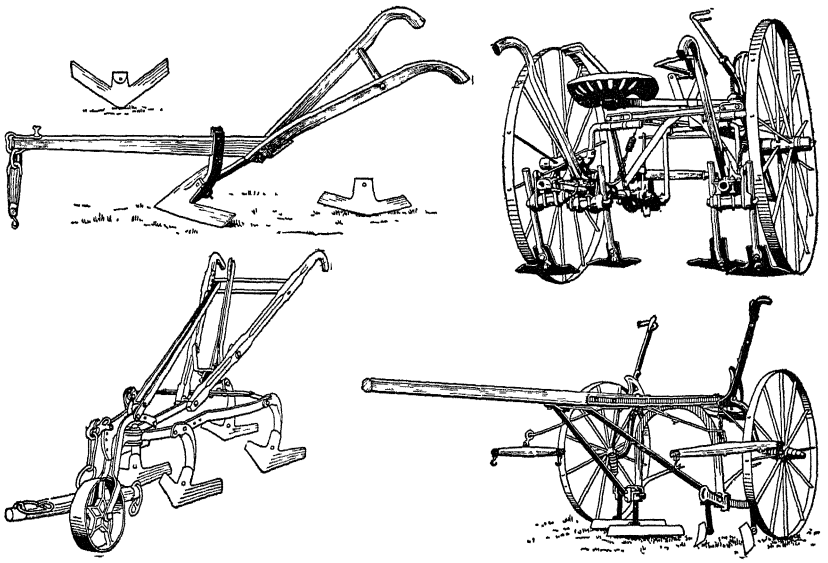

Fig. 12.—Various types of cultivators equipped with knife or sweep blades which cut thistle stems just beneath the surface of the soil. Courtesy of U. S. Dept. of Agriculture

Cultivation.—Cutting the green shoots below the surface of the ground may be done with cultivator, hoe, or spud. It is the best method for cultivated crops, such as corn, potatoes, sugar beets, etc. The field should be planted in check rows and cross cultivated. The cultivator should be fitted with knife or sweep blades as shown in Figure 12. These cut a few inches below the surface, which requires less labor and is more effective than deep plowing. More-

over, there is no danger of dragging roots from one place to another. Thistles close to the crop plants should be removed with hoe or spud.

Cultivation should begin as early as the conditions of the soil and the crop plant will permit. It should be repeated once in two weeks or in badly infested fields once a week as long as the corn or other crop plant can be cultivated. This method has been used with success by farmers who maintain clean fields and many reports give this as the method used. It requires a great deal of work and time and where the price of labor is high is expensive, but it is effective.

The after treatment of these fields is important, and according to reports received quite varied. Mr. C. E. Vensel, Otsego, Ohio, who had kept a thistle infested field continuously in corn and under clean cultivation for three years, writes, "I think one more year cultivation of corn will clean the field." Clean cultivation of corn followed by summer fallow and cultivation was reported as successful by George W. Timmins, agricultural agent of Marion County.

More often the infested field was left in a cultivated crop one year and followed by a rotation of crops, one member of the rotation being a smother crop.

Smother crops.—E. F. Townsend, agricultural agent of Perry County, reports the successful use of a heavy stand of grass as a smother crop. In the author's experience none of the usual tall farm grasses—timothy, orchard grass, or redtop—are effective. The stand is not dense enough to shade the thistles adequately nor are they cut early and often enough to keep thistles in check. Of the various smother crops tried, alfalfa and biennial sweet clover proved the best. Of the two, alfalfa is the better as it is cut earlier and oftener than sweet clover. After proper preparation of the soil and inoculation of the seed from 10 to 15 pounds to the acre should be sown to insure a sufficiently heavy stand. If the infested field has been in corn it may be sown to alfalfa after the last cultivation. If the field is to be in spring wheat or oats, the alfalfa or sweet clover should be seeded at the time the grain is drilled. If winter wheat is to follow the cultivated crop the smother crop should be sown broadcast in March or April. The usual procedure, cutting for hay and pasturing in late summer and fall, is followed. The thistles are often exterminated in one year, but it is best to leave the field in the smother crop a second or even a third year, when it should be plowed under and followed by a cultivated crop.

The following abstract from the report of E. B. Meeker, Tiffin, Ohio, will give in detail the successful eradication of thistles by

means of alfalfa. Canada thistles were so dense in 4 acres of an 18-acre wheat field in 1919 as to choke out the wheat. In April Mr. Meeker sowed alfalfa with a hand seeder on the wheat ground. The first cutting was made June 15 to 20 when the alfalfa was in full bloom. The second and third cuttings were made when the alfalfa was again in full bloom. The first crop of hay was nearly all thistles; but there were none to be found the second year. The field averaged 4½ tons of hay per acre per year and furnished an abundance of good pasture in the fall.

Mr. Frank Geisken, of Ottawa, Ohio, had similar success with sweet clover. A field in which the rotation was corn, wheat, clover, contained several patches thickly infested with thistles. The corn ground was disked for wheat, and biennial sweet clover was seeded in the wheat in the spring at the rate of 1 bushel to 8 acres. A thick stand was secured.

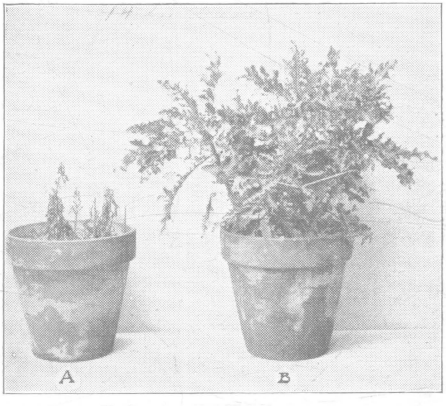

Fig. 13.—Effect on Canada thistle seedlings of shading by sweet clover

A. A dense growth of sweet clover in 3 months almost exterminated the thistles. The sweet clover was removed to show the thistles.
B. Thistles of same age and in adjacent crock in full light.

O. P. Shoots, Marion, Ohio, reports success with soybeans, but gives no details. The soybean, being an annual, cannot be as effective as alfalfa.

The use of smother crops is in general practice, especially in those parts of the State where permanent pastures are not maintained. This method requires less work than any other, yields valuable returns in hay and forage, improves the soil, calls for no expense in addition to seeding and harvesting the crop, keeps the fields in constant use, and is successful in subjugating the thistles, as they readily succumb if densly shaded. This is well illustrated by Figure 13. A dense growth of sweet clover in flower pot A (removed to show the thistles) in three months almost killed the thistles, B was entirely unshaded.

ERADICATION BY CHEMICALS—CALCIUM ARSENITE AND SODIUM ARSENITE

Based on the hope of finding an easily applied and effective means of destroying weeds, numerous tests were made during the past decade with different chemicals, usually applied as a spray. In 1924 it was decided to try chemicals on Canada thistles in permanent grass land.

The results of the author's previous tests with common salt (sodium chloride), iron sulfate or green vitriol (ferrous sulfate), sodium arsenate, and sodium arsenite on other plants led to the choice of sodium arsenite to be tested on thistles. The field selected was a heavily thistle infested permanent pasture at the Experiment Station. No previous weed eradication treatment had been given the pasture except to mow the thistles once or twice a year. They were massed in more or less dense patches throughout the field.

Calcium arsenite and sodium arsenite in the form of a commercial preparation were tried out.

The pasture contains 40 acres, part of which is thinly wooded. A small stream trending from southeast to northeast divides it longitudinally into a 25-acre eastern and a 15-acre western portion. Sodium arsenite was used on the eastern and calcium arsenite on the western portion. As the pasture had been quite heavily grazed by cattle and sheep; the grass stand was uneven, both in density and height. Several other weeds besides thistles were present. Because of the many stumps and the roughness of the area, a power sprayer of the orchard type was used.

The sodium arsenite, which was in solution, was diluted in the proportion of 1 part of the solution to 20 of water and applied on patches of thistle at the rate of approximately 100 gallons to the acre.

The calcium arsenite was a powder. As it is with difficulty soluble in water, it was applied as a suspension, 1 pound of calcium arsenite to 2 gallons of water and at a rate of approximately 50 gallons to the acre.

The first application of sodium arsenite was made on the afternoon of August 19, when about two-thirds of the east side of the pasture was covered. Spraying the east side was completed during the morning of August 21. The first application of calcium arsenite was made on the afternoon of August 21, when about two-thirds of the west side was covered. Due to a rather stiff breeze the application was ragged. A second spray was therefore applied September

23 on a part of the area sprayed August 21 and the as yet unsprayed portion was given its first application. Consequently, one-third of the west side of the pasture received two coatings, and two-thirds, one coating of calcium arsenite. The interval between these two partial applications was so long because the use of the sprayer could not be secured sooner. At this time the thistles had reached full maturity. Many were in bloom and many heads contained ripe seed. No further applications were made in 1924.

In order to ascertain the effect of these herbicides on the individual plants, 30 representative plots of thistles were selected for observation, 15 on the east and 15 on the west side. To be representative, some of these plots were chosen where the grass had been closely cropt, some in dense tall grass, some around stumps (situations very favorable to the thistles), some where the thistles were tall and vigorous, others where they were short and stunted. In each plot 10 individual thistles were staked and the stakes numbered consecutively, e. g., Plot 1 contained staked plants 1-10, Plot 30, staked plants 291-300. Each stake was set immediately to the west of the plant with its number facing the plant; so that if the aerial shoot were killed and removed the plant could be found. The entire plot in each case was measured, the distances between the most outlying stakes were used to delimit the plot. The general condition of all the plants in each plot was noted before and after spraying. Detailed notes were kept of each plot and its staked plants.

The first observation on the effect of the herbicides was made the second day after their application. The thistles treated with sodium arsenite were blackened and apparently killed to and just beneath the surface of the ground. White clover leaves and exposed stems were killed. Other plants as yarrow, *Achillea millefolium;* indian tobacco, *Lobelia inflata;* slender nettle, *Urticum gracilis,* were sere and brown. Sheep sorrel, *Rumex acetosella,* was sometimes killed, but quite often escaped injury. The slender rush, *Juncus tenuis,* which was very abundant, suffered no injury. The grass, which was mostly Kentucky bluegrass, looked sere and the blades were killed to near the base, but the base of the blades and the sheath-protected buds were green.

The effect of calcium arsenite was less immediate. The plants were coated with the dried chemical 24 hours after the application. Some thistle leaves were brown but others and much of the stems were green. In a week penetration had progressed far enough to completely kill the aerial shoots to a depth of 2 or 3

inches below the surface. Calcium arsenite continued to dissolve on the plant so that its effect was progressive and cumulative. The effect on the other broad-leaved plants was similar. Grass was less damaged than by sodium arsenite.

The efficacy of an herbicide on a perennial depends on the penetrability of the poison. If it does not penetrate the perennial structures (in the case of Canada thistles the creeping, propagating roots) enough to kill them and permeates only the annual parts, the result is the same as the annual death taking place prematurely and under control.

To determine, therefore, how far these two chemicals had penetrated, a large number of thistles were carefully lifted. To insure getting a plant with its immediate roots a block 2 feet square and from 2 to 3 feet deep was lifted and the thistles teased apart. The sodium arsenite in no case examined had penetrated beyond the base of the aerial shoot. The propagating root had not been entered, and consequently, was uninjured and left in a condition to produce new aerial shoots. The calcium arsenite, in three cases, had pentrated into the horizontal root.

In 1924 a detailed examination was made on October 6, 7, 8, and 10, from 17 to 49 days after treatment of these plots. The condition of the sprayed plants was noted and a count taken of the number of thistle shoots which had arisen from the roots and from the erect stems of the old aerial shoots. On the 15 staked plots sprayed with sodium arsenite there were 718 aerial shoots at the beginning of the experiment. These had been more or less completely killed to or a few inches below the surface of the ground; but on 21 thistles there were green sprouts from the base of the sprayed stalks. On one shoot a space 2½ by 1 cm. had escaped penetration by the herbicide. From the node in this space a thrifty sprout developed. There were 525 green shoots from the roots, and a total of 558 new rosettes.

The thistles on the 15 plots treated with calcium arsenite showed better penetration by the herbicide. There were 863 thistles before the treatment was begun and 143 came up afterwards from the roots. The majority of the sprayed shoots were rotten several inches below the surface. Seven of these plots had no new shoots by October 6, 1924.

The experiment was continued in 1925. A partial survey was made April 29, and a more complete one May 13, 1925, before treatment the second season was begun, to determine how well the thistles had survived the winter. The 15 plots sprayed with

calcium arsenite had 359 young thistles, a return of 42 percent. The 15 plots sprayed with sodium arsenite were so dense with young thistles that no count was taken.

On June 15, 16, and 23, 1925, the east side of the pasture was again sprayed with sodium arsenite of the same concentration and at the same rate of application as in 1924. Three efforts were necessary as but a part of the area was covered each time. The entire east side had now received two applications, with the exception of plots 25 and 26 which were in an enclosure reserved for other work and so not available. On July 1 the west side was again treated with calcium arsenite of the same concentration and at the same rate as in 1924.

On July 23, 1925, a careful survey was made of all the staked plots. The calcium-arsenite plots showed a return of a total of 31 plants or less than 4 percent of the original number, or an effectiveness of 96 percent. The sodium arsenite plots had a total of 362 new thistle shoots or 56 percent of the original number, an efficacy of 44 percent. The two unsprayed plots were not included. These figures are approximate only as the basis of the computation was the number of thistles at the beginning of the 1924 spray program. No allowance was made for the normal increase of thistles not treated.

The spray program of the pasture was discontinued in 1925. Results show that one application a season is insufficient to exterminate the thistles. Two or, if infestation be heavy, three thorough applications of calcium arsenite, the first made in June, or just as the plants are beginning to form heads, the subsequent sprays following at intervals of a month or six weeks, should be effective. In order that the same results be attained with sodium arsenite the solution must be so concentrated that practically all vegetation will be killed. A 1-20 solution, though killing tissues with which it comes in contact, seems to stimulate to growth more remote structures.

H. L. Sassaman, assistant nutrition chemist, in the Department of Animal Industry of the Station, analysed both arsenites for the arsenious (As_2O_3) acid present. The calcium arsenite contained 47.1 percent As_2O_3, and the sodium arsenite 18.8 percent As_2O_3.

Using calcium arsenite at the rate of 25 pounds, or 11.78 pounds of As_2O_3, per acre and sodium arsenite at the rate of 15 pounds solids, or 2.82 pounds As_2O_3, per acre, the former would be four times as strong as the latter. This will account for the greater efficacy of the calcium compound, but not for the fact that grass was injured more by the sodium arsenite.

Weather conditions immediately preceding, during, and immediately following spraying operations are important. A warm, bright, calm day with evaporation high enough to insure the rapid wilting and drying of the sprayed plants is ideal. The afternoon of August 19 was warm and bright, wind velocity 32 miles an hour. During the night 1.08 inches rain fell, but the aerial shoots had been killed before the rain commenced. August 21 was hot and clear; maximum temperature 87° and mean 74° Fahr., wind velocity 20 miles an hour. September 23 was clear with maximum temperature 65° and mean 51°. It was followed by warmer and continued clear weather.

June 15, 1925, was clear and hot, maximum temperature 95°, mean 80°, with wind velocity 26 miles an hour. The 16th was cooler, maximum temperature 88°. A light rain fell during the night. The 23d was cooler with a trace of rain. July 1 was warm and clear. The weather therefore favored the success of the experiment.

LIABILITY OF POISONING STOCK

As is well known, compounds of arsenic are poisonous to animals. Moreover, cattle, sheep, and hogs are very fond of the peculiar alkaline taste and ravenously eat herbage coated with arsenic. A fatal dose for a cow is estimated to be from 6 to 8 drams, or 10.5 to 28 grams Avoirdupois weight, and from one-fourth to one-third as much for a sheep. In order to determine how much arsenic was held by grass and how it persisted, analyses were made by Mr. Sassaman in 1925. He apportioned both east and west sides of the pasture into sections, and took 20 samples of sprayed grass from a section. Five grams of this collective sample was thoroughly dried and a quantitative analysis made for white arsenic, or arsenious acid As_2O_3. The samples were taken the day of the application of the spray on the east side and at intervals of a week for three months. When it rained samples were taken as soon as possible after the rain ceased. On the west side the first samples were taken July 8, one week after spraying and continued two and a half months. The samples were taken each time from the same sections but there was unavoidable variability.

The largest amount of As_2O_3 resulting from sodium arsenite on the day of spraying was .0188 gram from 5 grams of grass; after one week, .015; after three weeks, .0026; and after three months, .00065 gram. The largest amount of As_2O_3 resulting from spray-

ing with calcium arsenite, one week after its application was .0345 gram from 5 grams of grass; two weeks later, .0086 gram; and two and one-half months, .0082.

A cow in normal condition and under normal circumstances eats approximately 3500 grams pasture grass dry weight per day. This would be more if given no other feed. Taking the amount of As_2O_3 in 5 grams grass resulting from the sodium arsenite spray the day of application, its equivalent in 3500 grams grass would be 13.16 grams. An amount within the range of fatal doses. A week later it would be 10.5 grams, still a fatal dose; three weeks later 1.82 grams; and at the end of three months .45 gram. In the case of calcium arsenite the amount as found one week after spraying would be 24.15 grams As_2O_3 in 3500 grams grass dry weight; in two weeks 6.02 grams; and in two and one-half months 5.74 grams. These amounts showed a variability, not recorded here, due principally to the fact that in ordinary spraying, plants over even a very small area do not receive equal amounts of spray. This variability was reduced by taking 20 samples from each section, mixing them and taking 5 grams from the whole. It was impossible of course to cut more than once the same sample of sprayed grass. However, these results are sufficiently dependable to demonstrate that it is not safe to permit grazing animals to have access to arsenite sprayed plants until after one to three months has elapsed.

Other chemicals tested.—By request the Atlas Weed Killer, sulphide of soda, and nitre cake were tested on Canada thistles. An acre from the east side of the pasture and which had been sprayed with sodium arsenite in 1924 and 1925 was divided into one-third acre plots. The ground was densely infested with thistle rosette. These chemicals were applied August 14, 1925, at 1:30 to 2:30 p. m. The weather was clear and warm, maximum temperature 82°, mean 73°, with northwest wind 31 miles per hour.

Atlas Weed Killer (sodium chloride plus sodium hypochlorite plus probably a phenol) was used in three concentrations 1-4, 1-3, and full strength at the rate of 15 gallons to the section. The one-third acre treated with this compound was subdivided into 3 smaller plots. Leaves of plants sprayed with concentrations 1-4 and 1-3 wilted in 15 minutes and some were brown in 30 minutes. Under full strength of spray leaves wilted in 10 minutes. In all plots the leaf surfaces of various plants were coated with crystals of the salts. On August 21 a number of sprayed thistle shoots were still green at the tip. Several new rosettes had appeared. A 2-foot square block of thistles was lifted. Two of the shoots on this block

were green at the tip. The stems of the others were brown and dead 2½-5 cm. below the surface of the ground, all roots were alive and uninjured, and the buds were sprouting.

Sulphide of soda was used in the concentration of 1 pound of the sulphide to 1 gallon of water and at the rate of 15 gallons to the section, at 1:30 p. m. August 14. There was a strong sulphide odor. At 2 p. m. all broad leaved plants were olive brown, but not wilted; grass yellow. On August 21 a block was lifted. All leaves and some stems of the thistles were partially dead, others green to the apex. Buds were sprouting from these stems and from the roots two small rosettes had reached the surface.

Nitre cake ($NaHSO_4$) was used at a concentration of 2 pounds per gallon water and 15 gallons of solution to the plot, applied at 2:30 p. m. August 14. At 2:55 p. m. the broad leaved plants were yellow and wilted, grass also yellowed. There was a strong sour odor from the sprayed plants. On August 21 leaves of most thistles were brown, but 15 were green at top, and the stems of others were green. There were 28 new rosettes. Grass was severely injured. Smaller weeds were dead. A 2-foot square block of thistles bearing 3 shoots was lifted. One thistle was still green at the tip, the stems were but little injured beneath the ground. Several buds were evident on the stems.

CONCLUSIONS BASED ON THE SPRAY TESTS

Sodium arsenite, applied but once a season, even though in strong concentration, failed to kill the thistles because it did not penetrate the perennial root. If applied twice or three times a season it will doubtless kill the root through starvation. Its cost, $3 to $6 per acre for one application does not warrant its recommendation for use over large areas. Moreover, the pasture must be abandoned for two to three months after spraying. This proved beneficial to the grass stand.

Calcium arsenite was more efficacious than the sodium arsenite. It is not yet on the market and no cost estimate can be made.

Atlas Weed Killer was somewhat comparable in effect to strong brine but much more expensive. Being nonpoisonous animals may be kept in the pasture and being salt to the taste animals eagerly eat the sprayed herbage. It may be considered a control but not an agent of extermination.

Sodium sulphide lacked sufficient penetration to kill the deeper tissues. It was very disagreeable to handle.

Nitre cake has 30-percent available sulphuric acid and is a waste product in rubber plants. It should be inexpensive, but it lacked sufficient penetration to kill the deep seated horizontal roots and severely injured the grass. It was very unpleasant to handle, burning the skin as sulphuric acid burns.

The literature contains reports of tests made with a number of other chemicals but none of them seems sufficiently efficacious to merit an unqualified recommendation.

RECOMMENDATIONS

To sum up, the best control measures for grass lands which cannot be put under cultivation are persistent mowing, salting, and cropping and, where feasible, spraying twice during the season with a strong solution of a compound of arsenic. The last is best for fence rows and other waste lands inaccessible to stock. Salting in pastures to induce cropping is a fairly good control measure. Wherever possible infested grass lands should be plowed and sown to a smother crop to be followed after one, two, or three years by clean cultivation.

The value of preventive measures cannot be too strongly urged. The use of none but weed-free seed is of great importance. The extermination of Canada thistles on waste land, road and ditch borders, and fence rows is also very important. Infested tillable land should be sown to a smother crop as soon as possible in the rotation schedule, and this crop in due time be followed by clean cultivation.

STATE LAWS

The law passed by Vermont in 1795 appears to be the first recognition of the menace of the introduction of Canada thistles into the United States.

The Ohio legislature, either fearing an infestation or knowing that the plant had already become a pest, on March 6, 1844, passed a drastic law, "to prevent the introduction and spreading of the Canada thistle".

> Sec. 1. Be it enacted by the General Assembly of the State of Ohio, that every owner or possessor of land shall cut or mow down all the Canada thistles growing thereon, or in the highway adjoining the same so often as to prevent their going to seed, and if any owner or possessor of land knowingly shall suffer any such thistles to grow thereon, or in any highway adjoining the same and the seed to ripen so as to cause or endanger the spreading thereof, he shall forfeit and pay the sum of ten dollars; and any person may enter on the land of another, who shall neglect or refuse to cut or mow down such thistles, for the purpose of cutting or mowing the same down, and shall not be liable to be sued in an action of trespass therefor.

Sec. 2. That if any person shall, knowingly, vend any grass or other seed, in which there is any seed of the Canada thistle, such person shall, for every such offense, be fined the sum of twenty dollars.

Sec. 3. That all fines accruing under the provisions of this act shall be collected before a justice of the peace, in the name of the State of Ohio, and paid into the township treasury for the use of schools. This act to take effect from and after the first day of June next.

Section 2 of this law was amended on February 14, 1884 as section 7001 R. S. and expanded to cover other noxious weeds.

On April 29, 1885, a law was passed to compel owners of land to keep brush, briers, thistles and other noxious weeds cut on their respective sides of line or partition fences. This law was repealed in 1904 in House Bill 165 and for it was substituted another identical in purport but briefer in statement. The first paragraph follows:

Sec. 4240-1. An owner of land adjacent to a line or partition fence, shall keep all brush, briers, thistles or other noxious weeds cut in the fence corners and a strip four feet wide on his side along the line of a partition fence, but this section shall not affect the planting of vines or trees for use.

This weed law without a change occurs in the General Code of 1910 as Section 5942. In the General Code of 1910 under Section 13150 appears a slight modification of the impure seed law.

Sec. 13150. Whoever knowingly sells grass or other seed in which there is seed of the Canada thistle, white or yellow daisy or wild carrot or being the owner, occupier or possessor of land, permits a Canada thistle teasel or wild carrot to ripen seed thereon, or on the adjoining highway shall be fined twenty dollars.

The Agricultural Seed Law, to regulate the selling, offering or exposing for sale of agricultural seeds and to repeal sections 5805-1 to 5805-12 inclusive of the General Code was enacted in 1919. Parts of the law pertaining to Canada thistle follow:

Section 1. The term "agricultural seeds" or "agricultural seed" as used in this act, shall be defined as brome grass, Kentucky blue grass, Canada blue grass, fescues, Italian rye grass, timothy, alfalfa, alsike clover, crimson clover, red clover, white clover, sweet clover, Canada field peas, cowpeas, soybeans, vetches, barley, corn of all kinds, oats, rye, wheat, buckwheat, flax, kaffir corn, millets, sorghum, cabbage and all other grasses, legumes, cereals and forage plants which are sold, offered or exposed for sale within this state for seeding purposes within this state.

Section 2. Every lot of agricultural seeds, as defined in section one of this act, except as herein otherwise provided, when in quantities of ten pounds or more, except in case of rape when one pound or more shall be the quantity requiring a label, shall have affixed thereto in a conspicuous place on the exterior of each container of such agricultural seeds, a plainly written or printed tag or label in the English language stating:

(a) Commonly accepted name of such agricultural seeds.

(b) The approximate percentage by weight of pure seed present, meaning the freedom of such agricultural seeds from inert matter and from other seeds distinguishable by their appearance.

(c) The approximate total percentage of weight of weed seed; the term "weed seed" as herein used being defined as the noxious weed seeds listed in section three and all seeds not listed in section one as agricultural seeds.

(d) The name of each kind of seed or bulblets of the noxious weeds named in section three which are present singly or collectively as follows: (1) in excess of one seed or bulblet in each five grams of timothy, red top, orchard grass, Kentucky blue grass, Canada blue grass, fescues, brome grasses, perennial and Italian rye grass, crimson clover, red clover, white clover, alsike clover, sweet clover, alfalfa, and all other grasses and clovers not classified: (2) one in twenty-five grams of millet, rape, flax, and other seeds not specified in one or three of this sub-section: (3) one in one hundred grams of wheat, oats, rye, barley, buckwheat, vetches, and other seeds as large or larger than wheat.

Section 3. The term "noxious weeds" as used in this act shall include Canada thistle (Cirsium arvense), wild onion (Allium vineale), quack grass (Agropyron repens), dodders (Cuscuta species), plantains (Plantago species), wild carrot (Daucus carota), oxeyedaisy (Chrysanthemum leucanthemum), corn cockle (Agrostemma githargo), docks (Rumex species), chicory (Chichorium intybus), and such other weeds as the secretary of agriculture, the director of the Ohio state agricultural experiment station and the dean of the college of agriculture of Ohio State University may determine to be noxious and a menace in Ohio.

This law superceded the earlier one with a much heavier penalty for its violation than the twenty dollars fine of the previous enactment. This law and similar ones in other states, if enforced, would reduce the menace of Canada thistles and other noxious weeds.

SUMMARY

A survey of the literature was made to determine the correct name to be adopted. Of the nine names found it is evident that *Cirsium arvense* is to be preferred and it should be credited to Tournefort.

The variable and small seed crop was found to be chiefly due to the dioeciousness of the plant, which was established by growing and studying seedlings. Distinctions between carpellate and staminate heads, florets, and floral structures as well as variations from the typical species were noted. The variety *vestitum,* which is evidently a seedling, was grown from the seed. The seedlings segregated so extensively that every variety reported in the United States was represented. Six hybrids of *Cirsium arvense* have been reported from Europe. Lund and Rostrop reported four other variations which they designated as forms.

Conditions of growth as to soil, moisture, temperature, and light are the same as those best suited to wheat.

Seed production was found to be limited by the dioeciousness of the plants; by the failure of approximately 50 percent of the flowers formed to develop; by the failure of pollination, due doubtless to weather unfavorable to the visits of honey bees, which are the chief agents of pollination; and to destruction of seeds by insects.

The viability of Ohio seed of the current year ranged from 4 to 48 percent. The seed will germinate when ripe. At higher latitudes this percentage is greated; at lower, it is less.

An abstract of Duvel and Goss' tests of the longevity of the seed under field conditions is given.

The organs of propagation and dissemination are the seeds and the perennial adventitious bud-producing roots. These buds become the aerial green shoots or "thistles", which are annuals, or biennials, dependent upon the time when the shoot appears. Those which appeared in April to June bloomed and seeded the same season, those appearing later did not bloom until the second season.

The noxiousness of the plant is due to the character of the root system, the easy dissemination, and longevity of the seeds.

Septoria cirsii, which causes spots on the leaves, and *Puccinia suaveolens,* a rust which attacks stem and leaves are the most prevalent fungi. Neither seriously injures the host.

Six insects were found infesting Canada thistles in Ohio: *Pyrameis* (Vanessa) *cardui* L., the Painted Lady butterfly, which defoliates the plants; *Dasyneura Gibsoni* Felt, a midge fly, which infests young flower heads and prevents the development of the seeds; *Trypeta florescentiae* L, a dipterous fly, which devours the developing and fully developed seeds and is actively instrumental in reducing the seed crop; and a stem girdler, Crampus sp., and two species of aphis were also noted.

Canada thistles can be **controlled** by keeping the aerial shoots under subjection, thereby preventing seeding and the accumulation of food in the roots. Mowing, salting and cropping, cultivation, and spraying with chemicals that kill only the aerial parts are **control** measures. The best means of **eradicating** Canada thistles was found to be clean cultivation and the use of alfalfa or sweet clover as a smother crop.

Experiments testing the efficacy of chemicals as herbicides showed that none of those tested can be profitably used on large areas unless other means cannot be used.

BIBLIOGRAPHY

1. Arthur, J. C. Uredinales. North American Flora 7: 7, 511, 1922.
2. Ashmead, Wm. D. Descriptions of some new North American Chalcididae. Can. Ent. 20: 101-107, 1888.
3. Aslander, Alfred. Chlorates as plant poisons. Jour. Am. Soc. Agr. 18: 12, 1101-2 D 1926.
4. Ausserdorfer. Sched, 1. c. p 478, Tirol Sexten.
5. Bauhin, C. Pinax, p. 377, 1671.
6. ————Caspar. Pinax. 1623.
7. ————J. Hist. Plant 3: 59, 1651.
8. Beal, W. J. Michigan weeds. Mich. Agr. Col. Exp. Sta. Bul. 267 D, 1911.
9. Britton, N. L. Manual of the Flora of Northern States and Canada, 1901.
10. ———— and Addison Brown. Illustrated flora of the Northern United States, Canada and the British Possessions, 2nd. Ed., 1913.
11. Bull, C. P. Weeds. St. Dept. Agr. State of Minn. Bul. 43, 1925.
12. Burchard, O. Die Unkrautsamen, Berlin, 1900.
13. Calumna, Fabius. Ecphrasis, p. 45, 1616.
14. Coe, H. S. Weeds. So. Dak. St. Col. Agr. Exp. Sta. Bul. 150, 1914.
15. Coulter, John W. and Aven Nelson. New Manual of Botany of the Central Rocky Mountains, 1909.
16. Cox, H. R. Controlling Canada thistles. U. S. D. A. Farmer's Bul. 150, 1914.
17. Darlington, Wm. American Weeds and useful plants, 1883.
18. Dorph-Petersen, K. Rep. Int. Seed Testing Congress 7: 127, 1924.
19. Duysen, Franz. Unkraeuter, 1925.
20. Fedde, F. Index novarum Siphonogarum, Justs Bot. Jahresber. 36: pt. 2, 379, 1908.
21. Garman, H. Some Kentucky weeds and poisonous plants. Ky. Agr. Exp. Sta. Bul. 183, 1914.
22. Goller et Huter. Sched l. c. p. 311, Tirol Pustertal.
23. Goss, W. L. The vitality of buried seeds. Jour. Agr. Research 29: 7, 349-362, 1924.
24. Gray, Asa. New Manual of Botany, Illus. 7th Ed. 1908.
25. Gress, E. M. Pennsylvania weeds. St. Dep. Agr. Gen. Bul. 416, 15, 1925.
26. Hansen, Albert A. Canada thistle and methods of eradication. U. S. D. A. Farmer's Bul. 1002, 1918.
27. ————. Nineteen noxious weeds of Indiana, Purdue Uni. Agr. Exp. Sta., Circ. 106, 1922.
28. Hillman, F. H. Nevada weeds III, Nevada and other weed seeds. Nev. St. Uni. Agr. Exp. Sta. Bul. 38, 1897.
29. Hitchcock, A. S. and Geo. L. Clothier. Kansas weeds IV, fruits and seeds. Kan. Sta. Agr. Col. Bul. 66, 1897.
30. Hoffman, G. F. Deutschland's flora oder Botanischer Taschenbuch f. d. 1804.

31. James, Jos. F. A catalogue of the flowering plants, ferns and Fungi growing in the vicinity of Cincinnati. Jour. Cin. Soc. Nat. Hist., 1879.
32. Khek, Eugen. Allg. Bot. Zeitscher. 15: 1-4, 1909.
33. Linné Carl von. Species Plantarum 2: 1753.
34. Lund, Samsoee and E. Rostrop. Marktidselen, Cirsium arvense, D. Kgl. Danske Vidensk. Selsk. Skr. 6, Raekke 10: 1901.
35. Mohr, Charles. Plant Life in Alabama. Cont. U. S. Nat. Herb. 6: Jy. 31, 1901.
36. Morse, Richard and Ray Palmer. British weeds. 1925.
37. Mueller, Franz von. Illustrated description of thistles, Victoria, Australia, 1890.
38. Newberry, J. S. Catalog of the flowering plants and ferns of Ohio, O. Agr. Rep. 235-273, 1859.
39. Pammel, L. H. Weeds of the farm and garden 1917.
40. ———— and Charlotte King. Some new weeds of Iowa. Ia. Agr. Col. Exp. Sta. Circ. 98, 1925.
41. Petry, E. J. Weeds and their control. S. Dak. Col. Agr., Agr. Exp. Sta. Bul. 211, 1924.
42. Porter, Thomas Conrad. Flora of Pennsylvania, 1903.
43. Raii Syn. p. 194, 1686.
44. Robbins, W. W. and Breeze Bayack. The identification and control of Colorado Weeds. Colorado Agr. Col., Agr. Exp. Sta. Bul. 251. 1919.
45. Robson, Steven. British Flora, 1777.
46. Rostrop, E. Heterociske Uredineen in K. D. vidensk Selsk Forhandel, 1884.
47. Ruhmer, G. Jahrb. des K. Bot. Gaert. und Bot. Mus. Zu. Berlin 1: 224-259, 1881.
48. Rydberg, P. A. Flora of Colorado. Colorado Agr. Col. Agr. Exp. Sta. Bul. 100, 1905.
49. Scopoli Johann Anton. Flora carniolica 2: Ed. 2, 1772.
50. Scudder, Samuel H. The butterflies of the eastern United States and Canada 1: 469-487, 1889.
51. Stevens, O. A. North Dakota weeds. N. D. Agr. Col. Exp. Sta. Bul. 162, 1922.
52. Stone, A. L. Some Farm Weeds. Uni. of Wis. Agr. Col. Ext. Ser. Cir. 171, 1924.
53. Tabernaemontanus, Theodorus Jacobus. Neu volkommen Kraueterbuck Basil, 1687.
54. Tidestrom Ivar. Flora of Utah and Nevada. Contrb. U. S. Nat. Herb. 25: 1925.
55. Tournefort, Joseph. Pittonde Institut 1: 448, 1700.
56. Wimmer Fr. and H. Grabowski. Flora Silesiae Vratislaviae 3: 82-92, 1829.